

$$Bo = \frac{q''}{G \cdot h_{fg}} \quad (8)$$

[0041] The capillary number, Ca, ratios the viscous forces to surface tension forces

$$Ca = \frac{\mu \cdot G}{\rho \cdot \sigma} \quad (9)$$

where

[0042] μ [kg/m/s]=Viscosity of the liquid

[0043] ρ [kg/M³]=Density of the liquid

[0044] σ [N/m]=Surface tension of the liquid

[0045] The Weber number represents the ratio of inertial to surface temperature forces

$$We = \frac{D_h \cdot G^2}{\rho \cdot \sigma} \quad (10)$$

[0046] The estimation of critical heat flux for saturated flow boiling has been studied for channels larger than microchannels. One correlation is from Katto and Ohno [Katto, Y. and Ohno, H., Int. J. Heat Mass Transfer, v. 26(8), pp. 1641-1648, 1984]

$$q''_{co1} = c_k G h_{fg} We_k^{-0.043} \left(\frac{L}{D_h} \right)^{-1} \quad (11)$$

$$q''_{co2} = 0.10 G h_{fg} \gamma^{0.133} We_k^{-1/3} \left[\frac{1}{1 + 0.0031(L/D_h)} \right]$$

$$q''_{co3} = 0.098 G h_{fg} \gamma^{0.133} We_k^{-0.433} \left[\frac{(L/D_h)^{0.27}}{1 + 0.0031(L/D_h)} \right]$$

$$\gamma = \frac{\rho_v}{\rho_l}, We_k = \frac{G^2 L}{\rho_l \sigma}$$

$$C_k = 0.34, \text{ for } \frac{L}{D_h} > 150$$

$$C_k = 0.25 + 0.0009 \left[\frac{L}{D_h} - 50 \right], \text{ for } 50 \leq 150 \quad (12)$$

$$C_k = 0.25, \text{ for } \frac{L}{D_h} < 50$$

We_k is the length based Webber number, using the length scale of the channel length.

$$K_{k1} = \frac{1.043}{4 C_k We_k^{-0.043}} \quad (13)$$

$$K_{k2} = \frac{5}{6} \cdot \frac{0.0124 + D_h/L}{\gamma^{0.133} \cdot We_k^{-1/3}}$$

$$\text{for } q''_{co1} < q''_{co2}: q''_{co} = q''_{co1}$$

-continued

for $q''_{co1} > q''_{co2}$:

$$q''_{co} = q''_{co2} \text{ when } q''_{co2} < q''_{co3}$$

$$q''_{co} = q''_{co3} \text{ when } q''_{co2} \geq q''_{co3}$$

$$\text{for } K_{k1} > K_{k2}: K_k = K_{k1}$$

$$\text{for } K_{k1} \leq K_{k2}: K_k = K_{k2}$$

$$q''_{crit} = q''_{co} [1 + K_k (h_{1,s} - h_{1,in}) / h_{fg}] \quad (14)$$

For saturated flow boiling q''_{crit} equals q''_{co} . SR number is defined as:

$$SR = \frac{Bo \times (T_{wall,max} - T_{sat}) \times D_h}{T_{sat} \times L} \quad (15)$$

Where, Bo=Boiling number, dimensionless

[0047] $T_{wall,max}$ =Maximum temperature of the wall surrounding boiling section, K

[0048] T_{sat} =Saturation temperature of fluid at given pressure and composition, K

[0049] D_h =Hydraulic diameter of channel in which boiling is occurring, mm

[0050] L =Length of the channel over which boiling occurs, mm

The difference between the wall temperature and the saturation temperature is defined as the overage temperature. For a matrix of aligned microchannels where the local heat flux varies from channel to channel the difficulties described above become more challenging. Potential unit operations that would have a varying heat flux profile over a matrix of connecting channels include but aren't limited to the following: Exothermic chemical reactions, catalytic or homogeneous, distillation tower heat removal, desorption stage in an absorption or adsorption system, exothermic mixing processes, and the like. This can occur when the microchannels are aligned cross-flow to the direction of the other unit operation's channels. For the varying channel flux situation there may be need for more flow in channels with the higher heat fluxes and less flow to channels with less heat fluxes to sustain convective boiling.

PRIOR ART

[0051] The published literature does not reflect a consensus on the merits of microchannel boiling.

[0052] Boiling Regime and Heat Transfer Mechanisms

[0053] On one hand, some investigators have suggested that microchannel boiling is unique and possesses potential benefits over their macroscale counterparts. For example, Kandlikar (2002) performed a critical review flow boiling in channels with hydraulic diameter less than 3 mm. Based on this review, the following findings were made: